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(54) **METHODS AND SYSTEMS FOR PROVIDING MAPPING, DATA MANAGEMENT, AND ANALYSIS**

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USPC 345/422, 581, 603, 589, 593, 591, 605, 345/597; 703/2; 701/211, 532; 382/191, 382/293, 284, 128; 358/1.9
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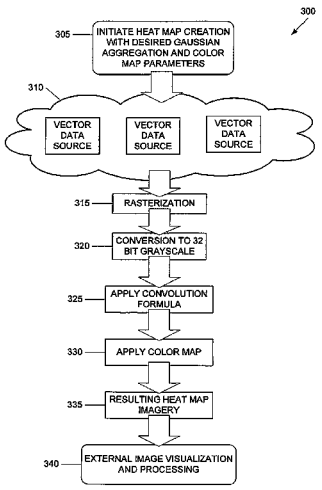
(57) **ABSTRACT**

A computerized method for providing mapping, data management, and analysis. A user request for creation of a map with a desired Gaussian aggregation and desired color map parameters is received. Vector geographic data is loaded at the server. The vector geographic data comprises location data, and the location data comprises an attribute. The vector geographic data is rasterized to create image data composed of pixels. The image data is converted to a certain scale grayscale image data. A convolution operation is performed on the grayscale image data to provide an aggregation of the data using a kernel radius, wherein the kernel radius is adjusted in accordance with the desired zoom level. Convolution results are applied to a color ramp; the map for the location data is created based on the color ramp and the convolution results, and the map is provided to the user.

32 Claims, 17 Drawing Sheets
(9 of 17 Drawing Sheet(s) Filed in Color)



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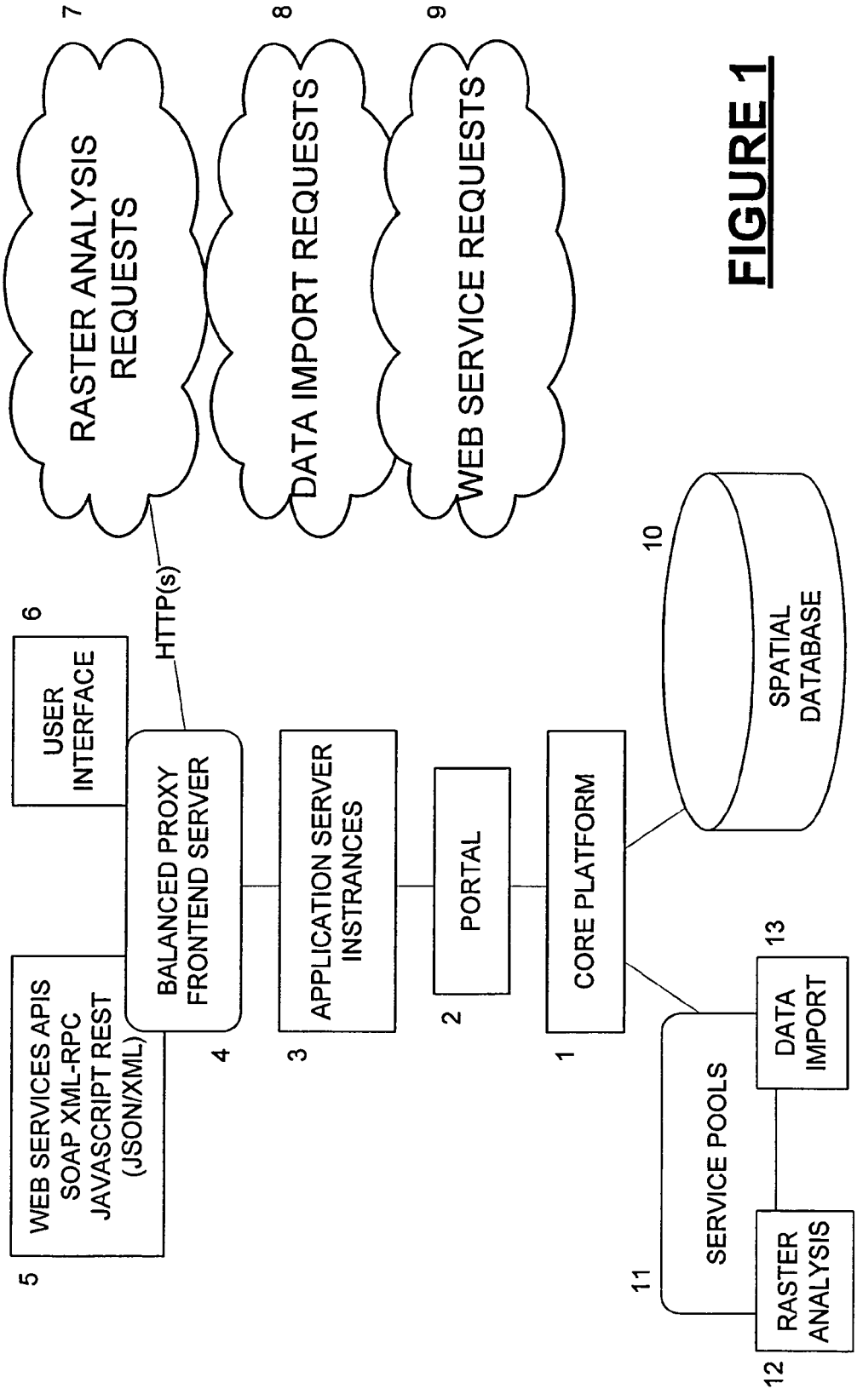

RASTER ANALYSIS REQUESTS
7
DATA IMPORT REQUESTS
8
WEB SERVICE REQUESTS
9
HTTP(s)
USER INTERFACE
6
BALANCED PROXY FRONTEND SERVER
4
WEB SERVICES APIS SOAP XML-RPC JAVASCRIPT REST (JSON/XML)
5
APPLICATION SERVER INSTRANCES
3
PORTAL
2
CORE PLATFORM
1
SPATIAL DATABASE
10
SERVICE POOLS
11
DATA IMPORT
13
RASTER ANALYSIS
12

FIGURE 1

FIGURE 2

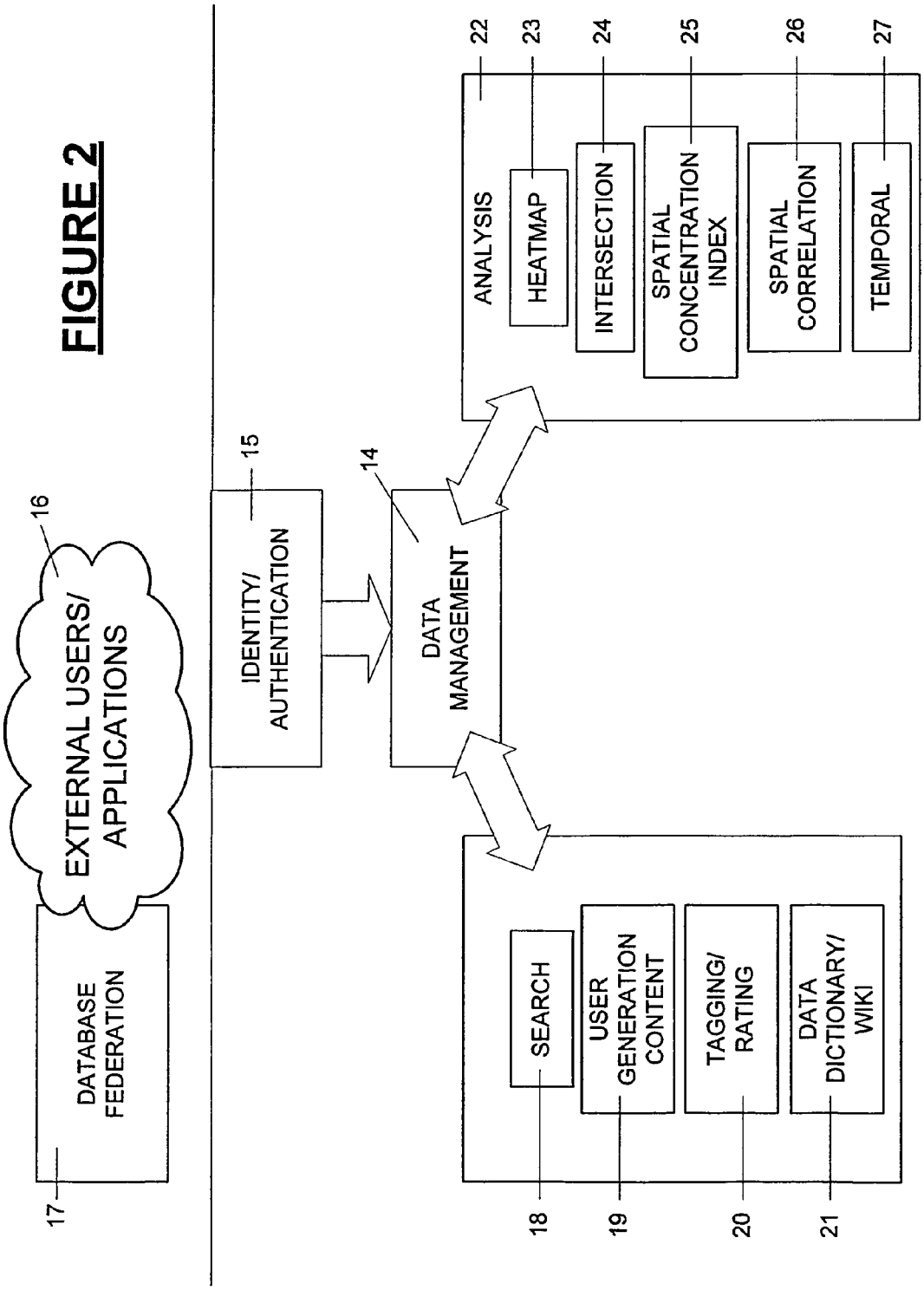

EXTERNAL USERS/ APPLICATIONS
16
IDENTITY/ AUTHENTICATION
15
DATA MANAGEMENT
14
ANALYSIS
22
HEATMAP
23
INTERSECTION
24
SPATIAL CONCENTRATION INDEX
25
SPATIAL CORRELATION
26
TEMPORAL
27
DATABASE FEDERATION
17
SEARCH
18
USER GENERATION CONTENT
19
TAGGING/ RATING
20
DATA DICTIONARY/ WIKI
21

FIGURE 3

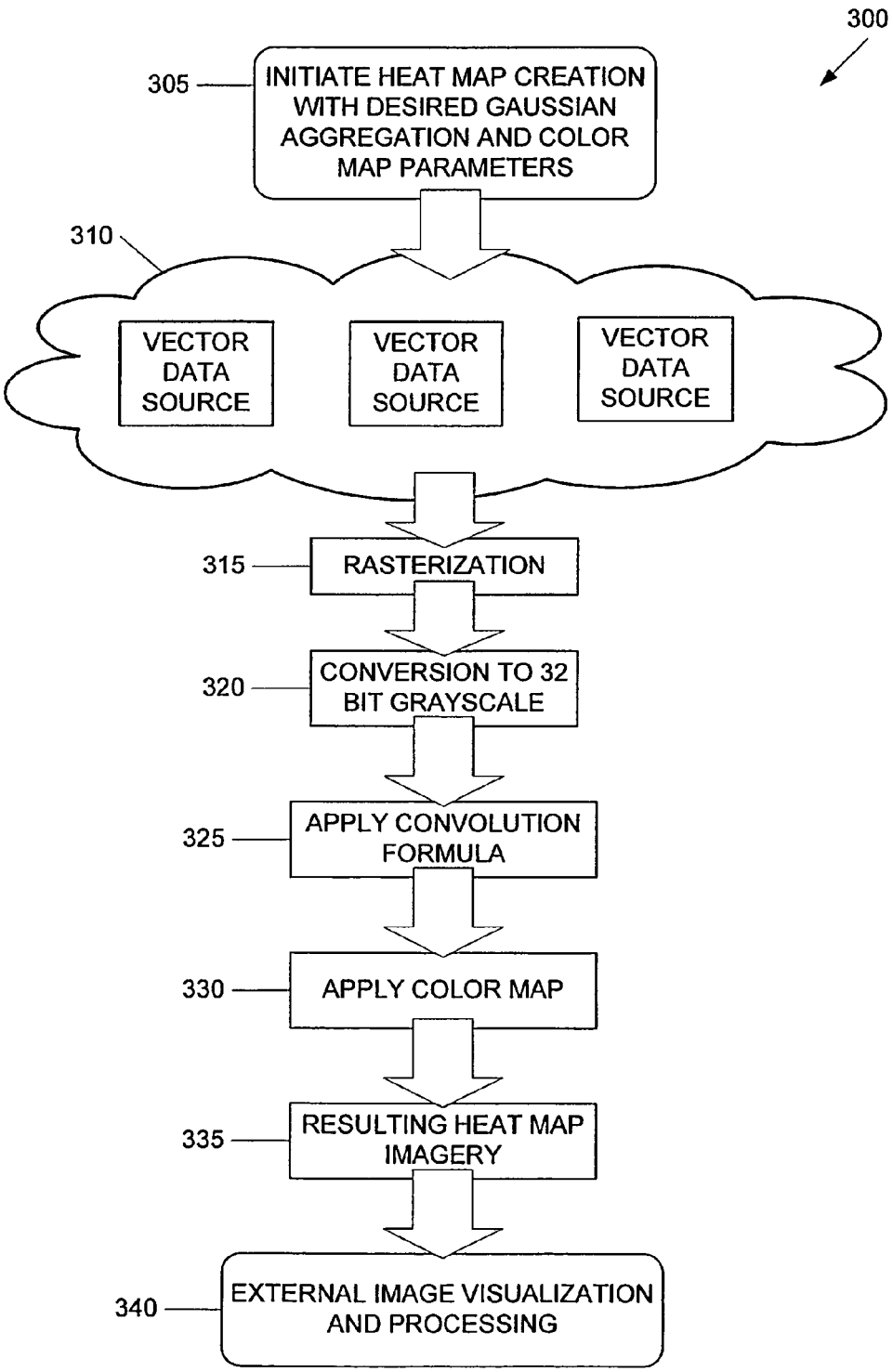

300
305
INITIATE HEAT MAP CREATION WITH DESIRED GAUSSIAN AGGREGATION AND COLOR MAP PARAMETERS
310
VECTOR DATA SOURCE
VECTOR DATA SOURCE
VECTOR DATA SOURCE
315
RASTERIZATION
320
CONVERSION TO 32 BIT GRAYSCALE
325
APPLY CONVOLUTION FORMULA
330
APPLY COLOR MAP
335
RESULTING HEAT MAP IMAGERY
340
EXTERNAL IMAGE VISUALIZATION AND PROCESSING

FIGURE 4

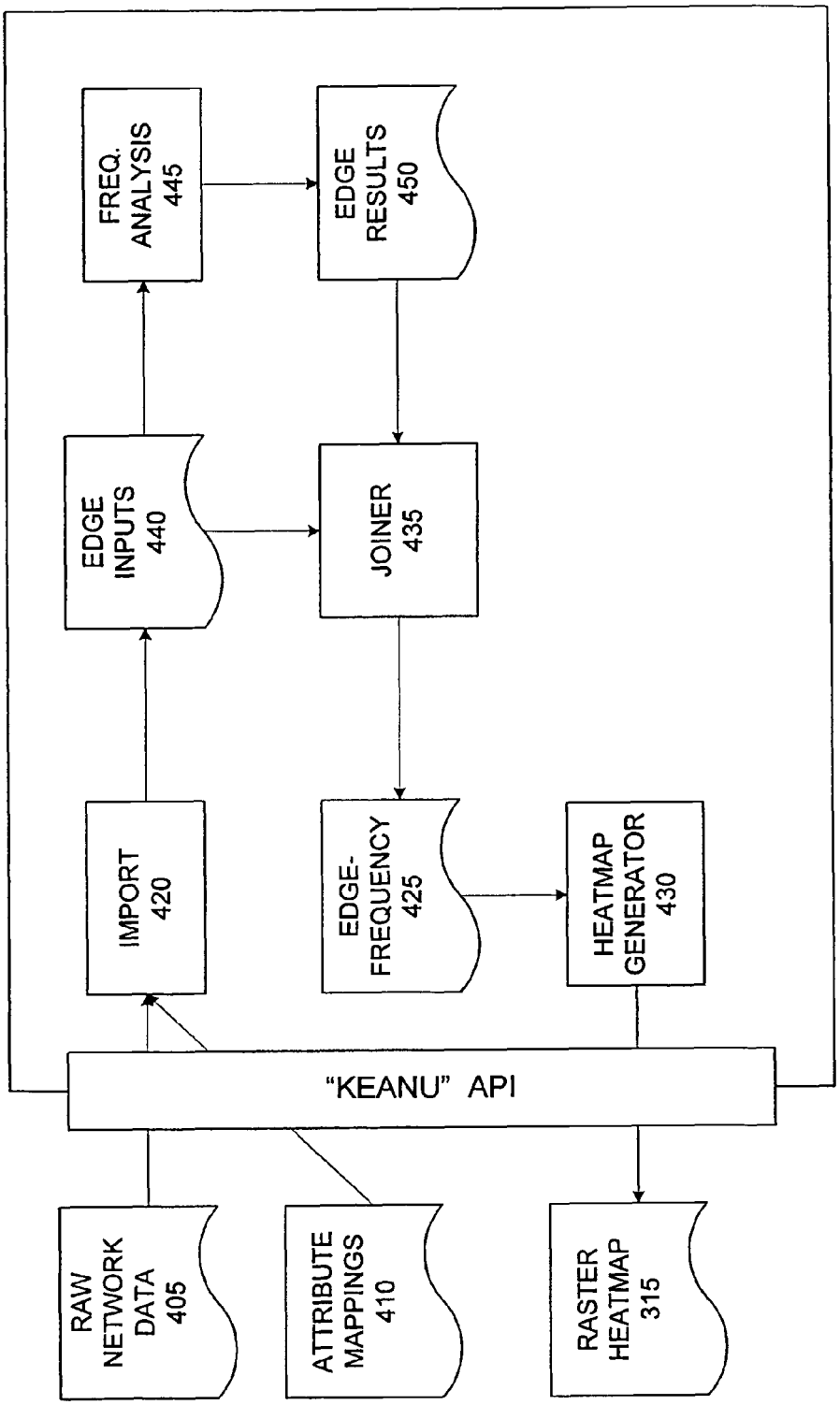

FREQ. ANALYSIS 445
EDGE RESULTS 450
EDGE INPUTS 440
JOINER 435
IMPORT 420
EDGE-FREQUENCY 425
HEATMAP GENERATOR 430
"KEANU" API
RAW NETWORK DATA 405
ATTRIBUTE MAPPINGS 410
RASTER HEATMAP 315

FIGURE 5

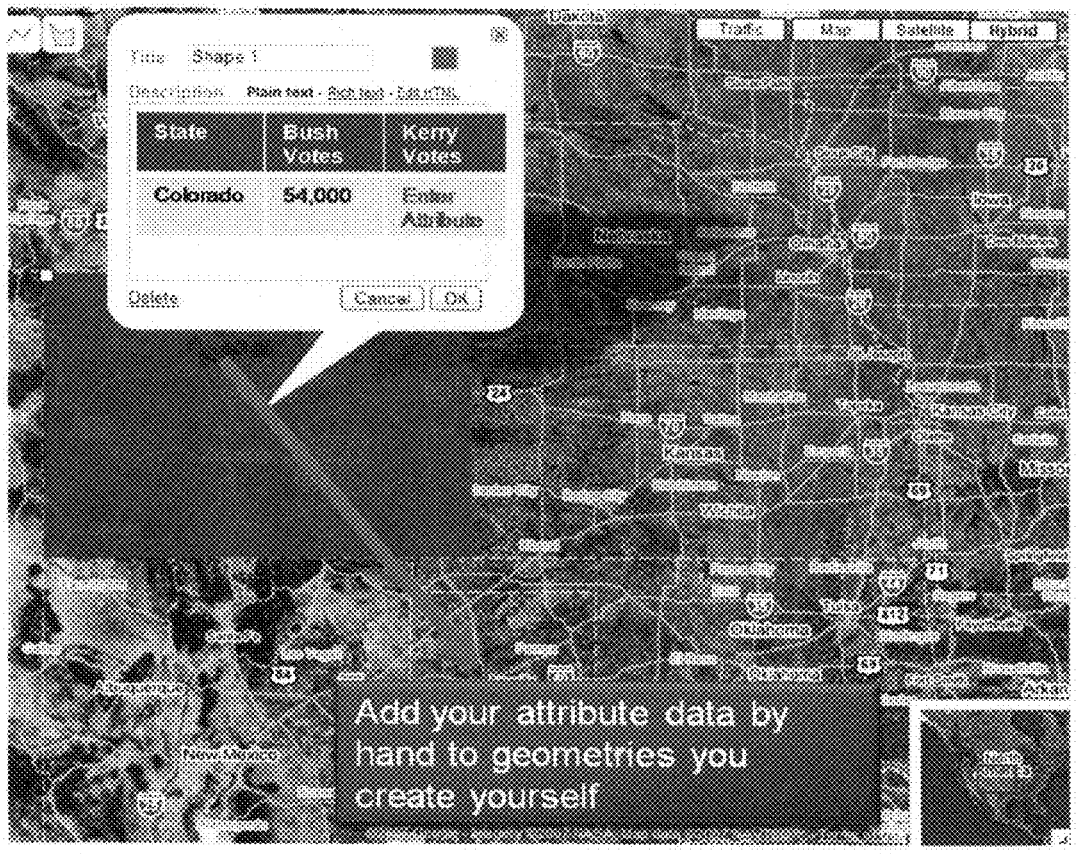

Title: Shape 1
Description: Plain text - Rich text - Edit HTML
State
Bush Votes
Kerry Votes
Colorado
54,000
Enter Attribute
Delete
Cancel
OK
Traffic
Map
Satellite
Hybrid
Add your attribute data by hand to geometries you create yourself

FIGURE 6

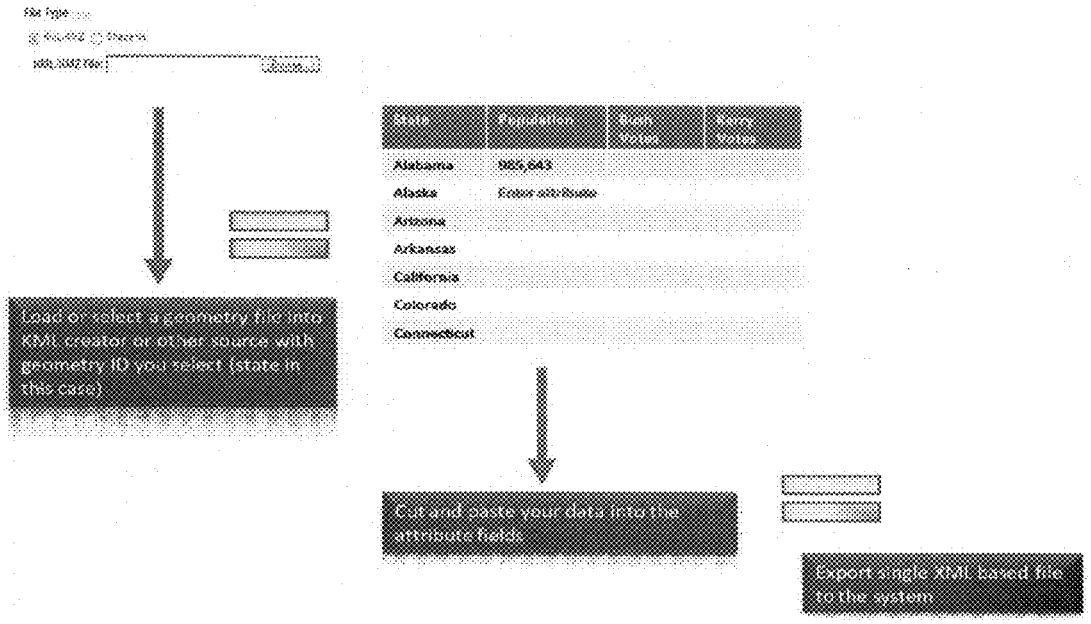

Load or select a geometry file into KML creator or other source with geometry ID you select (state in this case)
State
Population
Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Cut and paste your data into the attribute fields
Export single KML based file to the system

FIGURE 7

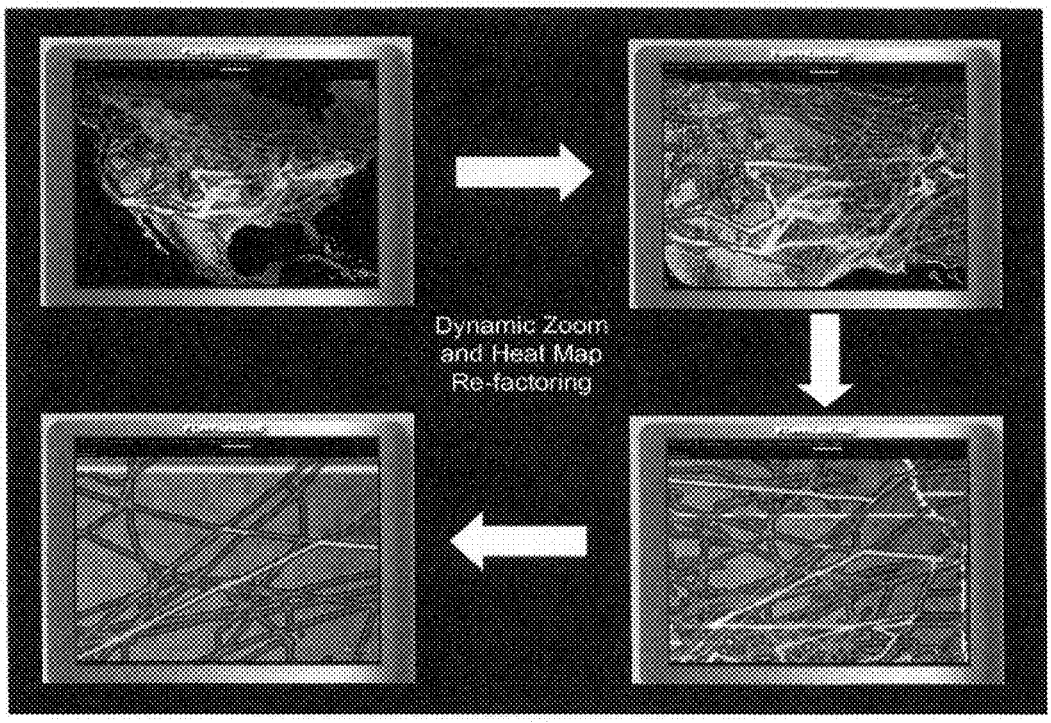


FIGURE 8

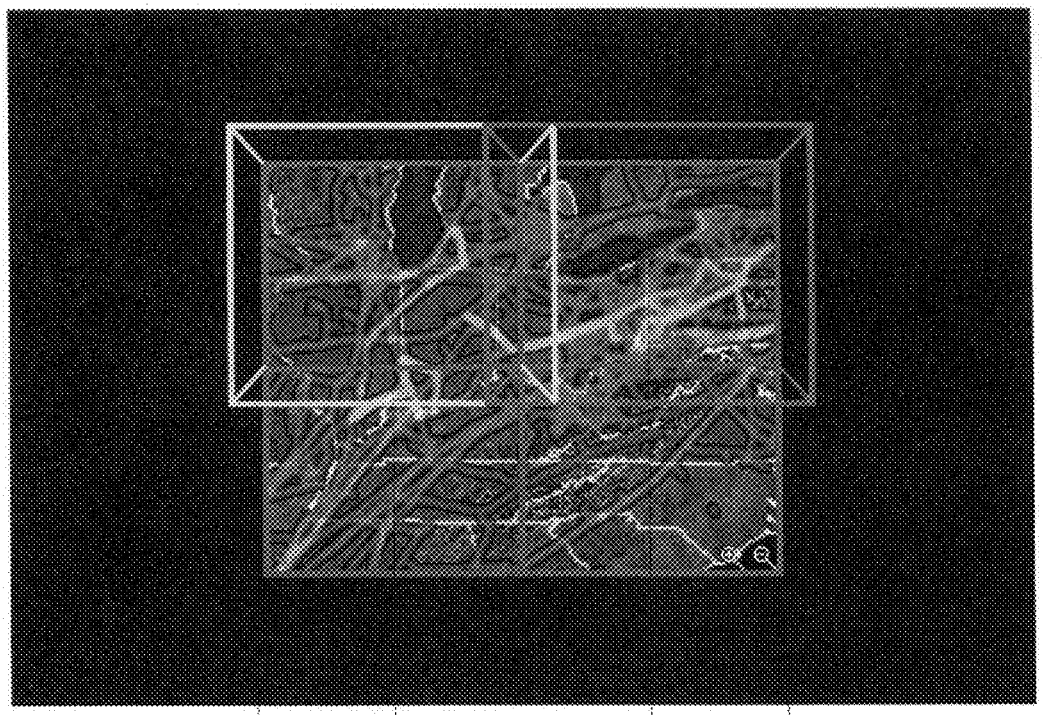


FIGURE 9

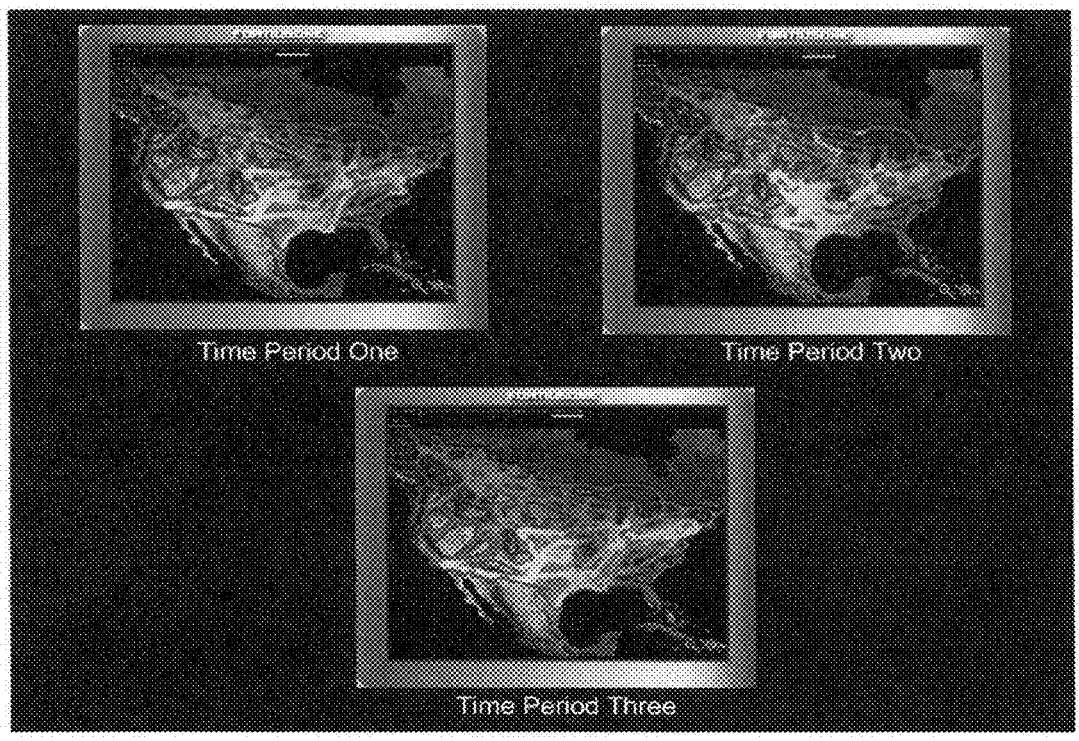


FIGURE 10

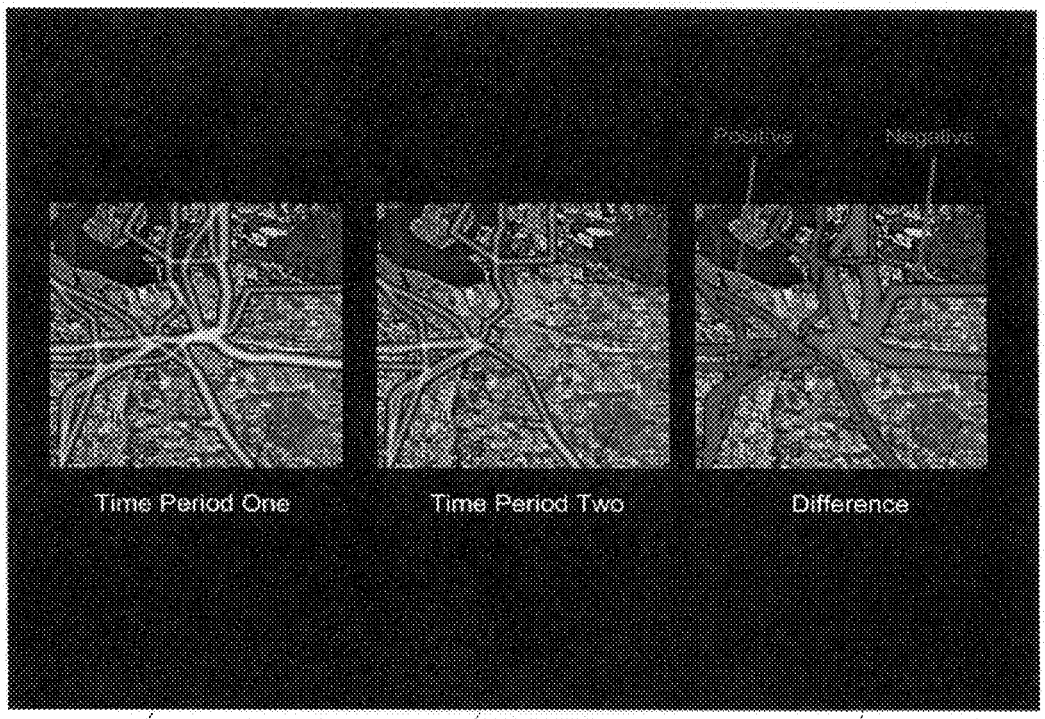

Positive
Negative
Time Period One
Time Period Two
Difference
1005
1010
1015

FIGURE 11

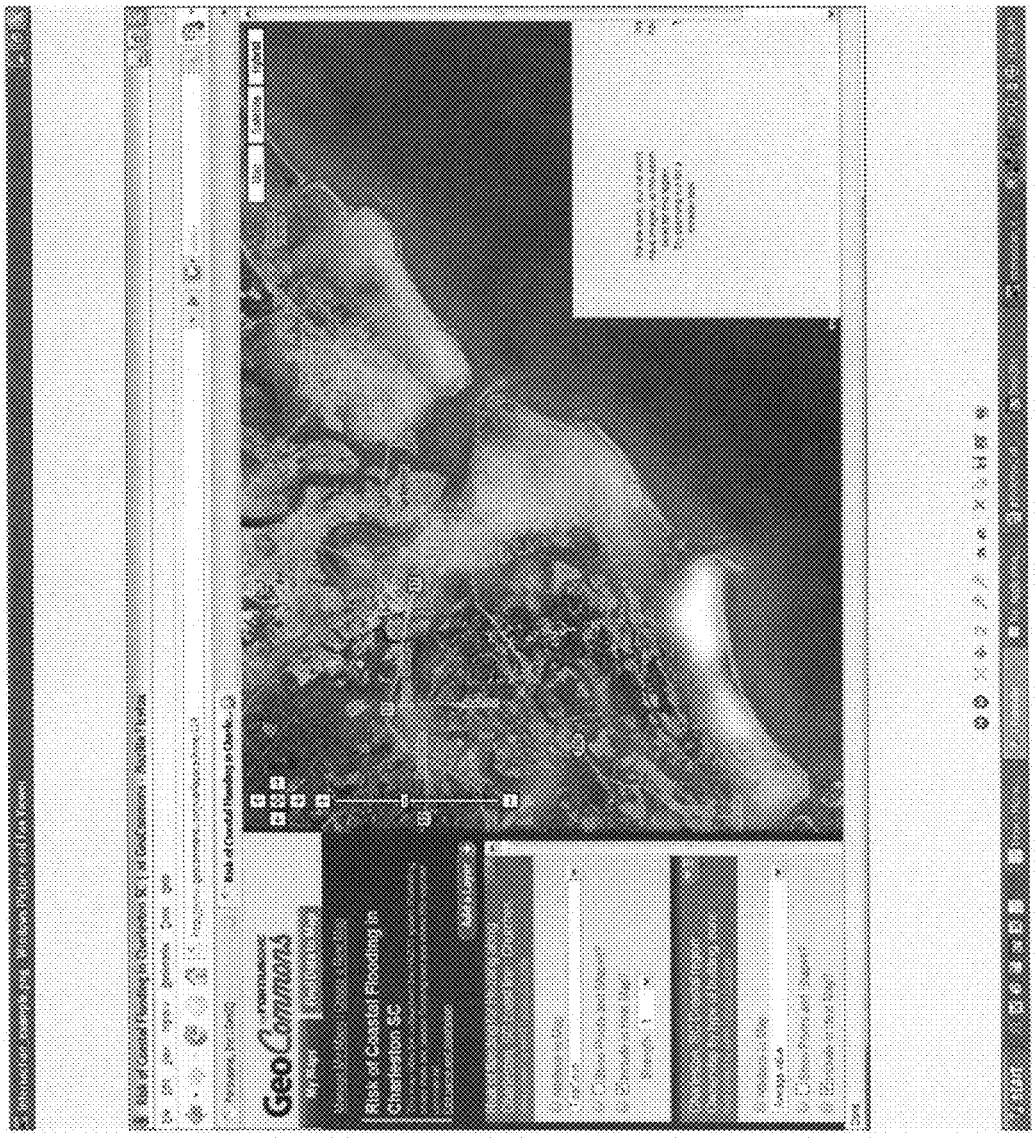


FIGURE 12

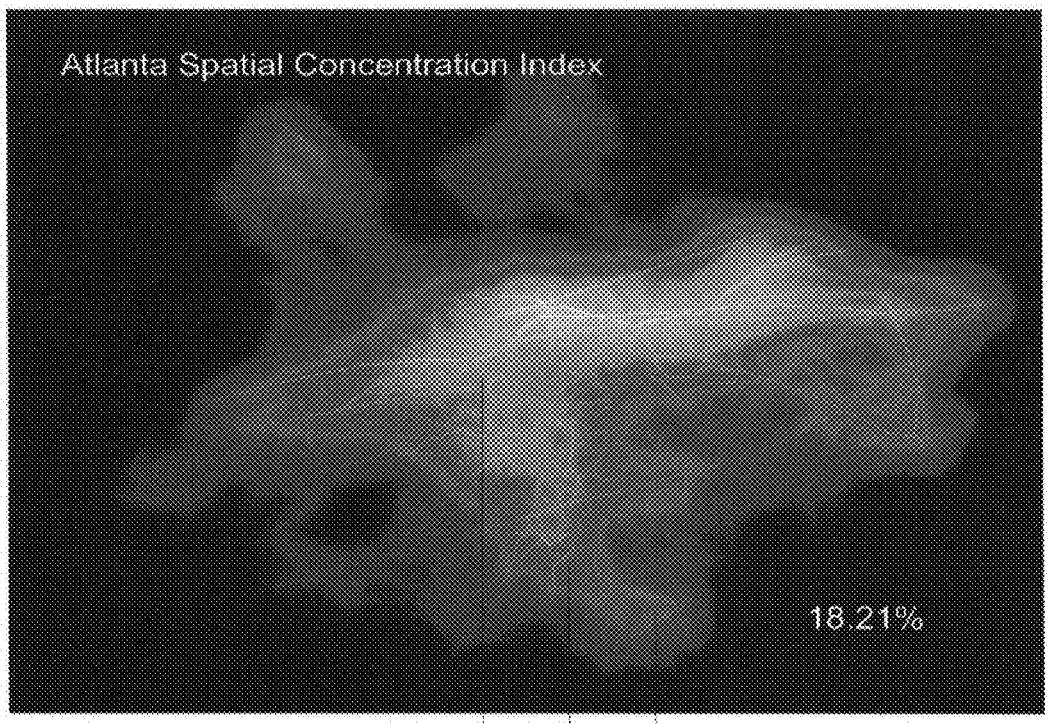


FIGURE 13

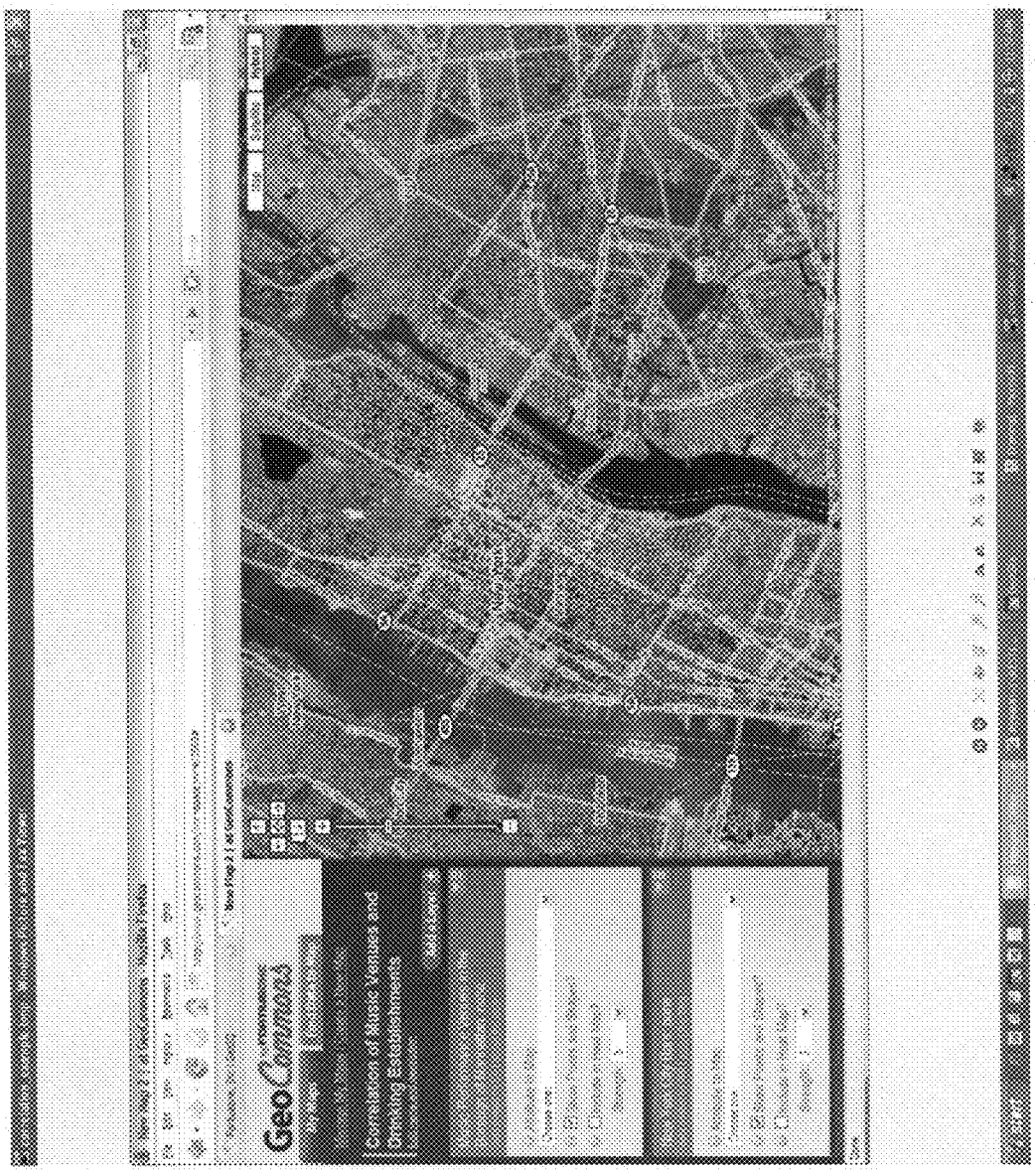


FIGURE 14

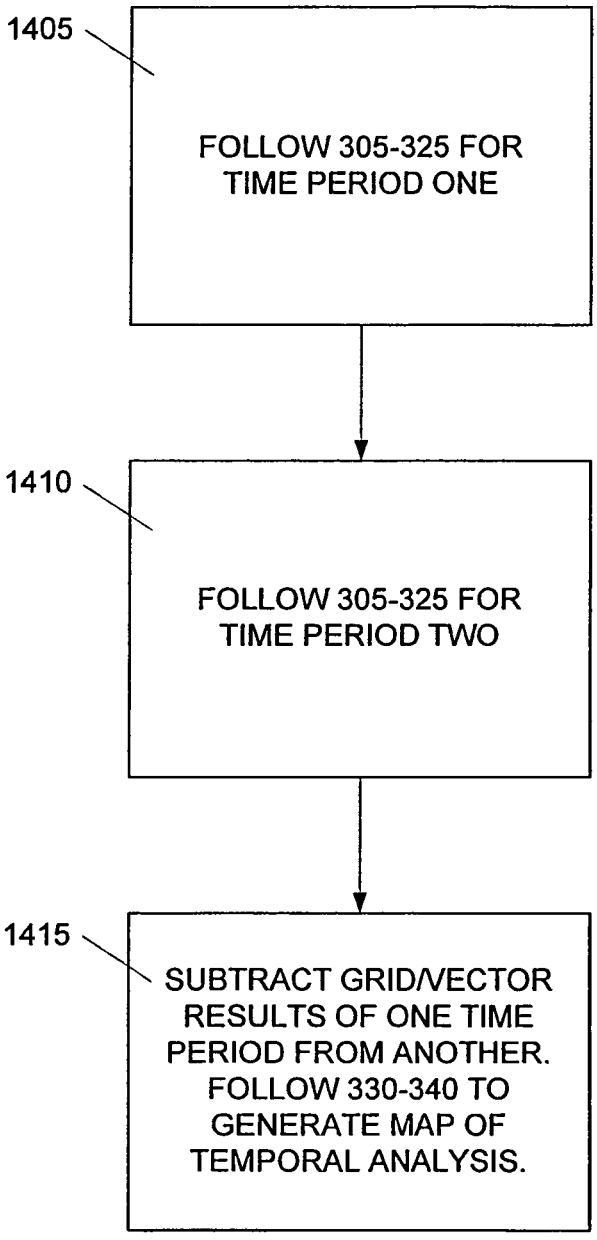

1405
FOLLOW 305-325 FOR TIME PERIOD ONE
1410
FOLLOW 305-325 FOR TIME PERIOD TWO
1415
SUBTRACT GRID/VECTOR RESULTS OF ONE TIME PERIOD FROM ANOTHER. FOLLOW 330-340 TO GENERATE MAP OF TEMPORAL ANALYSIS.

FIGURE 15

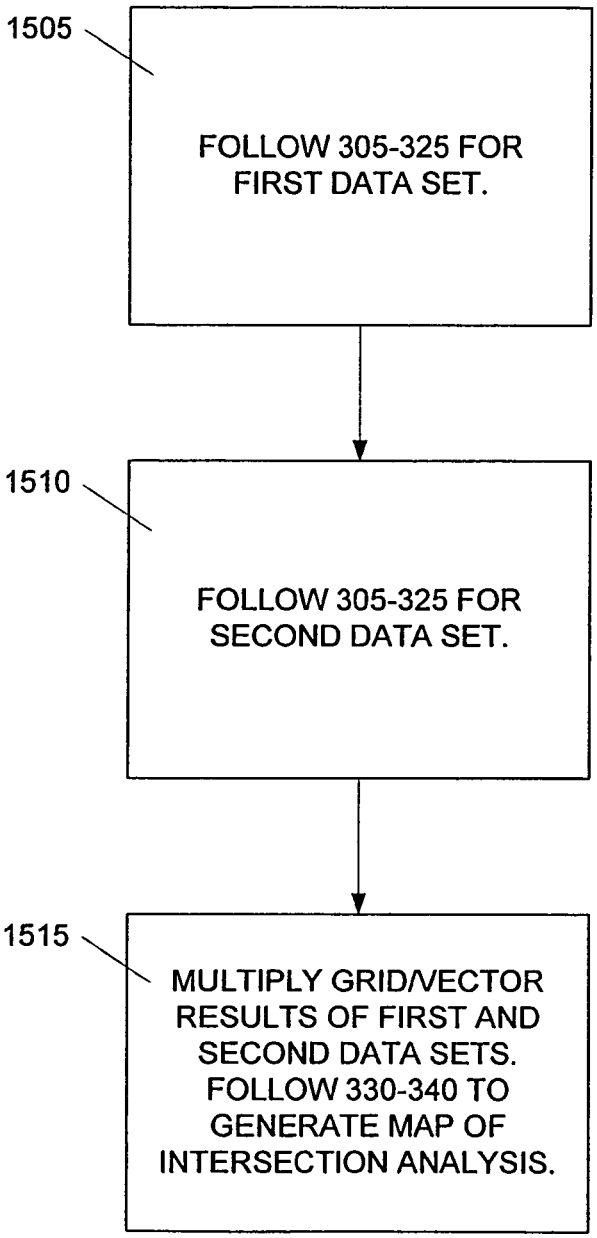

1505
FOLLOW 305-325 FOR FIRST DATA SET.
1510
FOLLOW 305-325 FOR SECOND DATA SET.
1515
MULTIPLY GRID/VECTOR RESULTS OF FIRST AND SECOND DATA SETS. FOLLOW 330-340 TO GENERATE MAP OF INTERSECTION ANALYSIS.

FIGURE 16

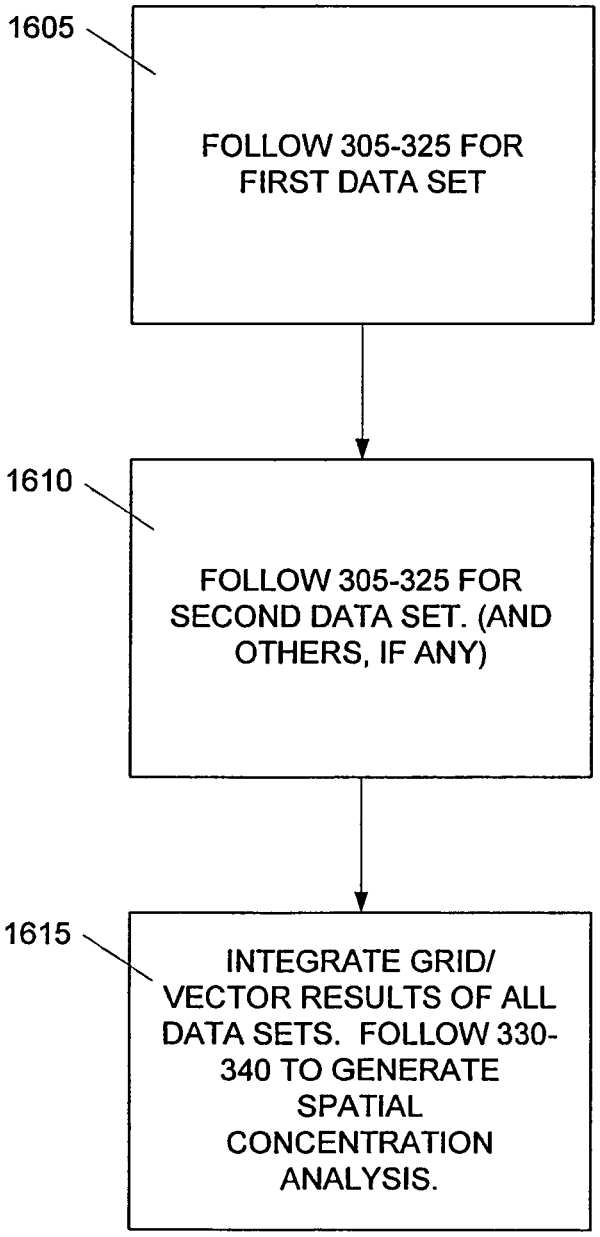
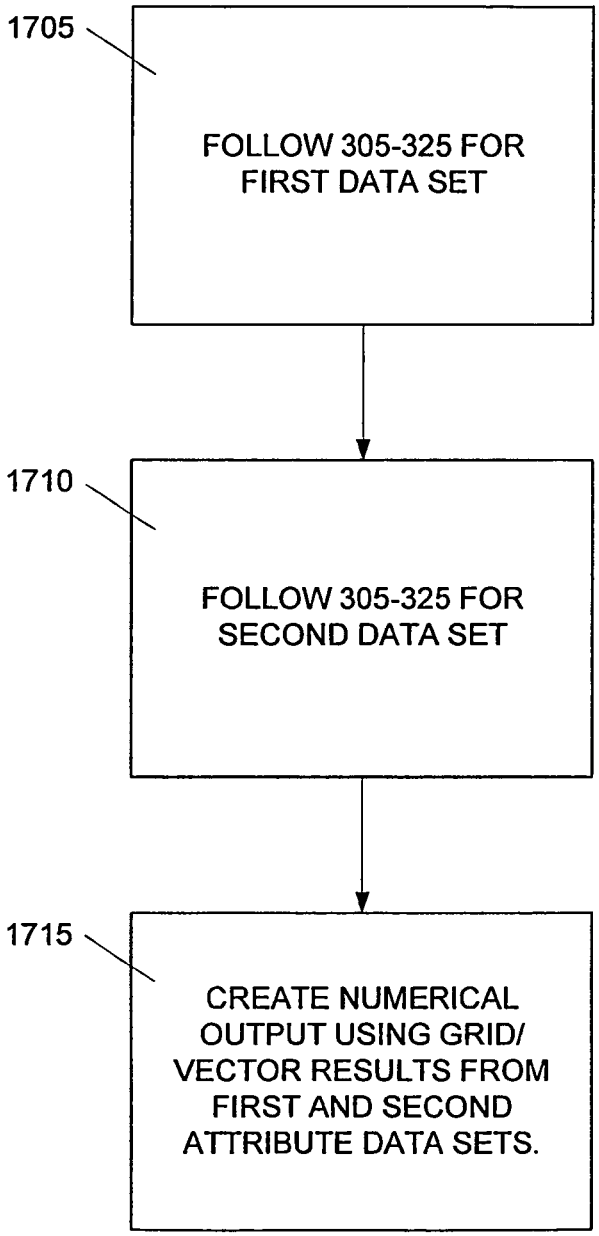

1605
FOLLOW 305-325 FOR FIRST DATA SET
1610
FOLLOW 305-325 FOR SECOND DATA SET. (AND OTHERS, IF ANY)
1615
INTEGRATE GRID/ VECTOR RESULTS OF ALL DATA SETS. FOLLOW 330-340 TO GENERATE SPATIAL CONCENTRATION ANALYSIS.

FIGURE 17


1705
FOLLOW 305-325 FOR FIRST DATA SET
1710
FOLLOW 305-325 FOR SECOND DATA SET
1715
CREATE NUMERICAL OUTPUT USING GRID/ VECTOR RESULTS FROM FIRST AND SECOND ATTRIBUTE DATA SETS.

METHODS AND SYSTEMS FOR PROVIDING MAPPING, DATA MANAGEMENT, AND ANALYSIS

This application claims priority to provisional application 60/824,913, filed Sep. 8, 2006, and entitled System and Method for Web Enabled Geo-Analytics and Image Processing, which provisional application is herein incorporated by reference in its entirety.

BRIEF DESCRIPTION OF THE FIGURES

The file of this patent contains at least one drawing executed in color. Copies of this patent with color drawings will be provided by the Patent and Trademark Office upon request and payment of the necessary fee.

FIG. **1** is a system diagram illustrating a mapping, data management and analysis system **100**, according to one embodiment.

FIG. **2** provides additional details on the core platform **1** of FIG. **1**, according to one embodiment.

FIGS. **3-4**, and **14-17** are workflow diagrams utilizing the mapping, data management, and analysis system **100**, according to several embodiments.

FIGS. **5-6** are examples of how a user may create attribute data, according to several embodiments.

FIGS. **7-13** are examples of different maps, according to several embodiments.

DETAILED DESCRIPTION OF EMBODIMENTS

FIG. **1** is a system diagram illustrating a mapping, data management and analysis system **100**, according to one embodiment. Using the system **100**, geo-analytics can be delivered utilizing a Web browser. Geo-analytics performs mathematical computations and/or analysis on geographic information. Geo-analytics delivered using a Web browser can enable entities to utilize geo-spatial applications (i.e., applications which gather, store, process and deliver geographical information) with Web 1.0 or Web 2.0 applications. Web 2.0 applications are applications that use a second generation of Web-based communications and hosted services, and facilitate collaboration and sharing between users.

The system **100** can include a core platform **1** (explained further in FIG. **2** and its accompanying explanation). The core platform **1** can provide many core functions of applications data management, including, but not limited to, data dictionaries/data wikis **21**, user generated content **19**, search capabilities **18**, database federation capabilities **17** (i.e., data pulled from outside system **100**), authentication and identification **15**, and analysis functions **22** (e.g., heatmap generation **23**, intersection analysis **24**, spatial concentration indexing (SCI) **25**, spatial correlation **26**, and temporal analysis **27**). The core platform **1** can manage all the data in the system and can link it to analysis modules that serve up results to the system **100**. All external data can be loaded through and managed by the core platform **1**, and all analysis of that data can be provided by the core platform **1** and delivered to the rest of the system **100**. The exposure of the core platform functions to the rest of system **100** can be handled by the portal **2**, which can serve as a gateway to the services in the core platform **1**. The portal **2** can then be linked to the application server instances **3**, which can handle the middleware connecting the core platform **1** to the outside world. The application server instances **3** can be managed by a balanced proxy front end server **4**, which can control the flow of traffic from the user interface **6** and Web services **5** (which can communicate using APIs (Application Programming Interfaces), SOAP (Simple Object Access Protocol) XML-RCP (eXtensible Markup Language-Remote Procedure Call), REST (REpresentational State Transfer), Javascript and/or any other technique). The user interface **6** enables a user to access the system **100** and the services it provides. The Web services **5** are the standard means by which a developer can access the services provided by the core platform **1**. Through either the user interface **6** or Web services **5**, the outside world can interact with the system **100** by sending requests routed through the balanced proxy server **4**. These requests can be for raster analysis **7** (including, but not limited to, heatmaps **23**, intersection **24**, spatial concentration **25**, spatial correlation **26**, and/or temporal analysis **27**). (More detail on the raster analysis requests **7** is provided in FIG. **2** and its accompanying explanation.) The raster analysis request **7** is routed to the core platform **1** which can locate the appropriate dataset from the database **10** for the analysis request and can process that data through the appropriate raster analysis module and then serve up the results using the service pools **11** for raster analysis **12** to create a portable network graphic (PNG) (or other compatible format such as GIFF, TIFF) of the results along with numeric output, if appropriate. Those outside the system **100** can also request to import a data set **8** to the core platform **1** using the service pools **11** for data import **13** that place the data in the spatial database **10**. (Details on how the data is managed is provided in FIG. **2** and its accompanying explanation). In addition to requesting analysis and adding data to the system, third party applications can be implemented in the system through Web service requests **9**. For instance a third party mapping application can be used to provide a layer in the application for the geo-referenced raster analysis **12**, as well as a reference upon which the data in the core platform **1** can be represented. Web service requests **9** are sent through the balanced proxy frontend server **4** to initiate Web services **5**.

As pointed out above, the system **100** set forth in FIG. **1** can enable entities to utilize geo-spatial, Web 1.0, and Web 2.0 technologies. Adding geo-analytics to media rich Web applications allows expanded computational and processing abilities. The system **100** can also be used with a variety of applications, including desktop applications and/or Web enabled systems. The analysis that is created can be used for one or more geographic scales. The user can zoom into the image to gain further detail and get an expanded picture of the original raster surface and/or additional detail regarding what specifically is causing the variation in attribute valuation. The user is also able to perform additional analysis using mathematical formulas the add data (e.g., SCI), subtract data (e.g., temporal analysis), multiply data (e.g., intersection), etc.

In addition, a broad, easy to use application can be provided to accommodate a non-technical user base. An understanding of the geo-spatial and mathematical concepts underlying the mapping application is thus not required. Many geo-analytics can be leveraged and simplified from the user's perspective to solve imminent real world problems for this new user set.

In one embodiment, the system **100** can be built with a geo-database back end using MY Structured Query Language (MY SQL) that allows geo-referenced data to be stored and queried. The data can be rated and tagged similar to what is implemented with Flickr (Flickr is an application that can provide photo sharing to consumers). Note that other tagging and rating systems can also be utilized. The tagging and rating system allows data to be to easily managed, pushing the most relevant and accurate data to the top of the hierarchy. The middleware of the application can be developed, in one

embodiment, using Ruby on Rails (Ruby on Rails is a middleware development platform that allows rapid building of media rich Web applications), providing a robust architecture for quickly building media rich Web applications to utilize a geo-database. Note that systems other than Ruby on Rails can be utilized. The front end can be developed, in one embodiment, in OpenLaszlo (OpenLaszlo is a middleware development platform that can integrate Macromedia Flash with html and dynamic html in a browser deployable environment without requiring plug-ins to be downloaded). Note that systems other than OpenLaszlo can also be used.

FIG. **2** provides additional details on the core platform **1** of FIG. **1**, according to one embodiment. The core platform **1** can provide both the analysis functions and database functions for the system. Data that is loaded into the system can be managed and served through the core platform **1**. When data is loaded with the service pools through the portal **2**, the user may be asked to provide tags/ratings **20** and a data dictionary of uploaded attributes and/or wiki descriptions **21** for each data set. The uploaded data can be either third party formats that already have attributes and features specified, or they can be user generated content **19** where the user defines the attributes and fills in the feature data for each attribute. These datasets can then be rated by other users of the system based on, for example, their accuracy, usefulness, and/or popularity. The combination of tags/ratings **20** and data dictionaries and/or wiki descriptions **21** provide a set of key words that can searched **18**, and the tags/ratings **20** can provide a means by which to rank the search results. Once data is loaded into the system **100**, analysis can be performed on it by the analysis modules **22**, which are explained in detail below in FIGS. **3-4** and **7-17** and their accompanying explanations. If the user selects a heatmap **23** (explained in more detail in FIGS. **3**, **7**, and **8** and their accompanying explanations), the analysis can produce a colored map illustrating where there are high number values for the data attribute selected. If the user selects an intersection analysis **24** (explained in more detail in FIGS. **11** and **15** and their accompanying explanations), the analysis can show the location where two data sets intersect each other. If the user selects the spatial concentration analysis **25** (explained in more detail in FIGS. **12** and **16** and their accompanying explanations), the analysis can use integration to illustrate how closely located different data attributes (e.g., infrastructures) are. If the user selects the temporal analysis **27** (explained in more detail in FIGS. **9**, **10**, and **14** and their accompanying explanations), the analysis can show the difference in values from one time period to another for the same set of data for a selected data attribute. If the user selects the spatial correlation analysis **26** (explained in more detail in FIGS. **13** and **17** and their accompanying explanations), the analysis can show how the data attribute from one data set is related to a data attribute from another data set. As described in FIGS. **3-4** and **7-17**, many of these analysis results can be communicated out of the system as a raster image. Accompanying numeric results can be communicated to external users and applications **16** because the raw data can be formatted in a variety of ways (e.g., tabular, unique instance). In addition to data in the core platform **1**, the system **100** can use database federation **17** to add data from a third party database that can be analyzed by the analysis modules.

FIG. **3** is a workflow diagram **300** utilizing the mapping, data management, and analysis system **100**, according to one embodiment. The workflow diagram **300** illustrates how a raster based analysis can be performed which can pertain to any of the analysis functions **22** outlined in FIG. **2** and its accompanying explanation. In **305**, heat map creation is initiated with a desired Gaussian aggregation (e.g., search radius) and desired color map parameters. In **310**, the desired vector data source is loaded from the data management object **14** in the core platform **1**. In **315**, the vector data source can be turned into a grid using rasterization. Rasterization is the conversion of images described in terms of mathematical elements (such as points and lines) to equivalent images composed of pixel patterns that can be stored and manipulated as sets of bits. In **320**, conversion to a certain scale (e.g., 32 bit grayscale) is performed. Once it is converted, in **325**, convolution can be applied to the grid/matrix. Convolution can be applied by taking the grid/matrix and applying a kernel distance decay function. The kernel distance decay function can be based one of many mathematical applications, including, but not limited to, a Gaussian distribution, an exponential formula, a linear formula, a power law formula, a logarithmic formula or a step function formula. The speed at which the kernel distance decay formula is applied can be enhanced by several mathematical applications, including, but not limited to Fourier transformations for convolution, and separable kernels (i.e., if the grid/matrix is one column and one row, when separated, the resulting matrix is expressed as a product of all columns and all rows). In addition, values between attributed data can be interpolated using approaches including, but not limited to, nearest neighbor approach, inverse distance approach, kriging, and splining. In **330**, once the convolution operation has been performed on the grid/matrix, the results of the operation can be applied to a color ramp where the color indicates a range of number values resulting from the mathematic operation. In **335**, the resulting image can then be created based on the color ramp and mathematical output. In **340**, the external visualization and processing can be done to produce a PNG or other suitable graphics interchange format.

FIG. **4** is a vector density analysis setting forth details of inputting vector data sources **310**, according to one embodiment. Example analysis include temporal analysis **27** (using subtraction), intersection analysis **24** (using multiplication), spatial concentration analysis **25** (using addition/integration), and spatial correlation analysis **26** (using a linear correlation coefficient). FIG. **4** illustrates a sample process where output from a network analysis system is integrated. The raw network data **405** is imported **420** as edge inputs **440**, which are points that are connected to each other (e.g., edge inputs **440** can be connections between electrical power substations **1**, **4**, **7**, and **8**). Each one of these edge inputs **440** can have one or more attributes **410** mapped to it (e.g., attributes of substations can be maximum voltage, number of lines, etc.). Based on the edge inputs **440** and the attributes **410** that are imported, a frequency analysis **445** can be run. In such an analysis, different routes can be run across the network and each time an edge is used it is counted as part of its frequency utilization (e.g., counting how many times edges connecting substations **1**, **4**, **7**, and **8** are used). The edge results **450** of the frequency analysis can then be joined **435** to the original geometry file identifying which edge frequency **425** the result belongs to. The edge frequency is the number of times the edge is used (e.g., how many times the edge connecting **1** and **4** is used). The edge frequency **425** can then be utilized to perform a raster analysis with the heatmap generator **430** and sent out to the system **100** as an raster heatmap image **315**.

As pointed out above with respect to FIG. **3**, data is entered in **310** that is used to generate the heat map. Many formats can be utilized to allow data (e.g., a geometric location) to be specified and described. It is sometimes useful to allow multiple attributes to be associated with a location or data point. In one embodiment, data structures can be feature attributes, so that quantifiable metrics can be parsed from the data to

analyze. This can be done by placing the feature attribute data in the schema tag of any XML based language in a structured way that allows it to be machine parsable. For instance:

```
<Schema name="City" parent="Placemark">
<SimpleField name="Name" type="string" />
<SimpleField name="Population" type="int" />
<SimpleField name="Temperature" type="int" />
<SimpleField name="Crime Rate" type="int" />
</Schema>
<City>
<Name>Nowheretown</Name>
<Population>300</Population>
<Temperature>76</Temperature>
<Crime Rate>25</Crime Rate>
</City>
```

From this code the system knows that geometry is a placemark on the map. That placemark is a city with the name Nowheretown and it has the following attributes—a population of 300, a temperature of 76, and a crime rate of 25. The city has a location and string of attributes that allow analysis to be done by the system.

While the above code is useful for a machine to read, in another embodiment, the system **100** allows a user to easily create attribute data to describe the numeric and textual features of a location. The following two methods, for example, can be utilized. For the first method (illustrated in FIG. **5**), the user creates fields for the attributes they would like add to a geometry (e.g., point, line, or polygon) or set of geometries. For example, the fields State name, Bush Votes, and Kerry Votes can be created. The user then fills in the fields for each point created on the map.

For the second method (illustrated in FIG. **6**), the user loads a set of predefined geometries with attributes in an easy spreadsheet interface. The user then selects from a list of predefined geometric boundaries (e.g., countries, states, counties, zip codes, provinces) or they upload a file with geometric boundaries they would like to use as a reference. From the geometric boundary file/selection, the user chooses the field (unique identifier) they would like to join data to (e.g., State name, city Name, FIPS code, identification number etc.). The user then adds the additional fields they would like to supply attribute data for. The user can enter the attributes by hand or cut and paste the attributes from another source.

Similar configuration data from other formats can also be converted to this structure, so that information resident in several systems can be put into a single format that is easily transferable over a network. Once the data is in an open standard single file format that is easily parsable, the data can be easily served up and analyzed in a Web browser environment. The data can be stored in a variety of database configurations and accessed through any number of middleware languages and served to the analytics engine.

Once the data has been entered in **310**, the remainder of the process set forth in FIG. **3** generates a heat map. The heat map can then be dynamically regenerated as the image is zoomed into, panned across, or as the attribute data changes (e.g., the heat map for weather would change as new temperature values were uploaded to the system). For example, a user can zoom to a certain level of specificity or pan across an area by changing the desired Gaussian aggregation in **305** of FIG. **3**. An example of the dynamic zooming and/or panning capability is provided in FIG. **7**. FIG. **7** illustrates real time pipeline flows in a particular city. One color (such as yellow) can be utilized to indicate the areas of the city where there is the most frequent use of the pipelines. Another color (such as purple) can indicate the areas of the city where there is less frequent user of the pipelines. Zooming can be performed by setting a kernel radius at each geographic level of granularity. When the user zooms in to a level of specificity, the kernel radius is set to match the geographic level of interest or the radius can stay the same and the number of pixels can change due to the size of the window viewed.

The map can also change based on the original attributes in the data source **310** of FIG. **3** changing. An example of the attribute changing capability is provided in FIG. **8**. The addition of buffered bounding boxes allows dynamic rendering and refactoring of heat maps by the user. When the attributes change the pixel valuation determination is run again to produce a new image. The speed at which the image processing occurs can be enhanced by, for example, Fourier transforms for convolution and/or separable kernels. As shown in FIG. **8**, an image is given geographic bounding boxes such as **805** (which is illustrated in FIG. **8** by an inside box, which can be green) or **810** (which is illustrated in FIG. **8** by an inside box, which can be green) based on the original coordinates of the attributed data. In addition to the bounding boxes **805** and **810**, a buffer **815** (which is illustrated in FIG. **8** by an outside box, which can be yellow) and **820** (which is illustrated in FIG. **8** by an outside box, which can be red) for each box is set based on the Gaussian distance decay function to produce an image outside of the viewing bounding boxes **805** and **810**. Thus, when the viewer moves to the next tile or zooms in and out there is a continuous buffer **815** and **820** creating a seamless image. Since the result of the analysis is an image (e.g., PNG, JPEG, TIFF, BITMAP), it can be created as a single overlay onto a variety of geo-referenced maps or surfaces following the process described in FIG. **3**. This image can be easily viewed in a Web browser after being sent to a user's Web browser following a request from the user. Each time the user pans, zooms, etc., a new request is sent from the user, and a new image is sent to the user's browser

The heat maps can also be analyzed based on applying additional mathematical processes to the method illustrated in FIG. **3**, according to several embodiments of the invention. Example analysis include temporal analysis (using subtraction), intersection analysis (using multiplication), special concentration analysis (using addition/integration), and spatial correlation analysis (using a linear correlation function).

FIGS. **9**, **10** and **14** illustrates data that changes in a temporal fashion. The attributed features of a geometry or set of geometries can have a temporal data aspect to it such as a date or time stamp. Using the generic XML style example previously cited temporal data could follow the following form:

```
<Schema name="City" parent="Placemark">
<SimpleField name="Name" type="string" />
<SimpleField name="Population 1900" type="int" />
<SimpleField name="Population 1920" type="int" />
<SimpleField name="Population 1940" type="int" />
<SimpleField name="Population 1960" type="int" />
<SimpleField name="Population 1980" type="int" />
<SimpleField name="Population 2000" type="int" />
</Schema>
<City>
<Name>Nowheretown</Name>
<Population>300</Population>
<Population>400</Population>
<Population>500</Population>
<Population>600</Population>
<Population>700</Population>
<Population>800</Population>
</City>
```

From the user interface side the data would have the following visual layout

City Name	Population 1900	Population 1920	Population 1940	Population 1960	Population 1980	Population 2000
Nowheretown	300	400	500	600	700	800
Enter Location	Enter Attribute					

Now that the system has a set of a series of temporal data points the map can visualize the change over time either as a series of static maps (e.g., FIG. **9**) or a map showing the difference (e.g., FIG. **10**). If a series of maps are created, the maps can be animated, for example, sequenced as a timed animation using any number of standard methods. The dynamic heat mapping approach can also be used to re-render heat maps on the fly as real time data changes or is dynamically updated. FIG. **9** illustrates the changing heat map of real time pipeline flows at three different time periods, according to one embodiment. For each map (e.g., one, two, or three), the method illustrated in FIG. **3** is followed using the data points for the particular time period (e.g., one, two or three) as the vector data source **310**.

In addition to dynamically visualizing real time data flows, the approach can also provide temporal analytics for change over time. For instance, did a certain geography or asset increase or decrease between the two time periods. FIG. **10** is a map illustrating map **1015**, which is the difference in flow between two time periods (map **1005** representing pipeline flow of time period one, and map **1010** representing pipeline flow of time period two). For map **1015**, geographies that gained flow (e.g., there was an increase in pipeline use) can be illustrated in one color (such as green) and those that lost flow (e.g., there was a decrease in pipeline flow) can be illustrated in another color (such as red). Map **1005** is time period one, map **1010** is time period two, and map **1015** is the difference between map one **1005** and map two **1010**. FIG. **14** is a method illustrating how map **1015** is generated, according to one embodiment. In **1405**, **305-325** of the method illustrated in FIG. **3** are followed, using the data points for time period one as the vector data source **310**. In **1410**, **305-325** of the method illustrated in FIG. **3** are followed, using the data points for time period two as the vector data source **310**. In **1415**, the grid/vector results of **325** for time period one is subtracted from the grid/vector results of **325** for time period two. The map **1015** for the temporal analysis can then be created by following **330-340** of the method illustrated in FIG. **3**.

Another example of analysis that can be applied is illustrated in FIGS. **11** and **15**, which illustrate the intersection of data, according to one embodiment. For example, if two or more images for two or more different data sets (weighted or unweighted by an attribute) are added, the results could be an image illustrating where those two data sets intersected each other and the color would indicate the proximity and magnitude (if weighted by an attribute) of those two or more data sets. FIG. **11** illustrates intersection map **1115**. For example, map **1115** could illustrate areas where pipelines and possible earthquake locations intersect, thus illustrating areas of possible flooding. FIG. **15** is a method illustrating how map **1115** is generated, according to one embodiment. In **1505**, the grid/vector result for the first data set can be created by following **305-325** of the method illustrated in FIG. **3**, and using the data points for the first data set as the vector data source **310**. In **1510**, the grid/vector result for the second data set can be created by following **305-325** of the method illustrated in FIG. **3**, and using the data points for the second data set as the vector data source **310**. In **1515**, map **1115** for the intersection can be created by multiplying the grid/vector result of for the first data set by the grid/vector result of the second data set. The map **1115** for the intersection analysis can then be created by following **330-340** of the method illustrated in FIG. **3**.

FIGS. **12** and **16** illustrate a spatial concentration index (SCI) analysis, according to one embodiment. FIG. **12** is an example of a spatial concentration index (SCI) for a city for five attributed infrastructures (electric power, natural gas, crude oil, refined products, and telecommunications). The SCI calculates the geographic concentration of any number of attributed data by measuring the geographic space separating the various assets and weighting it by the appropriate attribute. In **1605**, **305-325** of FIG. **3** is followed for each attribute data set. In **1615**, the grid/vector results of **325** for each attribute data set are integrated together. Then **330-340** of FIG. **3** are applied to the result in order to map the SCI. Thus, based on the calculation of distances between attributed data and what the values of those attributes are, a concentration index can be calculated. If all the attributed data in the study space are directly on top of each other the index would be 100. If no attributed data is in the study space the index would be 0, and various distributions of attributed data will results in varying indexes based on the concentration of the attributed data. FIG. **12** illustrates an SCI of 18.21. Note that one color **1205** (such as yellow) could illustrate the most concentrated area, another color **1215** (such as purple) could illustrate the least concentrated area, and varying distributions **1210** between the two colors could be illustrated by other colors.

The SCI can also integrate the real time data analytics discussed above. For instance the SCI could be determined in real time based on the actual flows though the infrastructure. Also, a risk index could be calculated based on real time hazard data like wind speed or storm surge from an approaching hurricane. As the threat ebbs and flows in magnitude or direction the SCI would dynamically recalculate to indicate the risk exposure as the real time threat evolves.

The SCI approach is not confined to calculating only risk parameters, but can also be used on a wide variety geospatial data providing geo-analytic decision support across a number of verticals. Consumers can hook in local searches, such as Yahoo Local and Google Local, and determine which location has a higher SCI of businesses they find attractive. This data can then be mashed up with demographic information to provide geo-analytics to support consumer and business decisions. For instance does neighborhood "A" or neighborhood "B" have a high concentration of young singles and highly rated bars? From the business perspective does neighborhood "A" or neighborhood "B" have a low concentration of competing coffee shops and a high concentration of individuals making over $100,000 per year?

FIGS. **13** and **17** illustrate a correlation analysis, according to one embodiment. Suppose there are two or more sets of sufficiently overlapping geometries, each ranked by a different attribute. It is possible to compute a score that measures how related those attributes are, for the area in question. For

example, if a data set was loaded with 25 store locations and second data set was loaded with the location of households who make over $100,000, an analysis could be run to see what the spatial correlation was between the stores and people who make over $100,000.

To compute the correlation score (note that a numerical output and not a map output is provided in the correlation analysis), in **1705**, **305-325** of FIG. **3** are followed for the data set for the first attribute. In **1710**, **305-325** of FIG. **3** are followed for the data set for the second attribute. In **1715**, a numerical output is created using the grid/vector results of the first and second attributes. At this point, we can compute a score by using the traditional linear correlation coefficient:

$$r = \frac{1}{n-1}\sum\left(\frac{x_i - < x >}{s_x}\right)\left(\frac{y_i - < y >}{s_y}\right)$$

In the above equation, in one embodiment, two data sets, X and Y, are compared. X includes a set of values x_i, i=1 to n. Similarly Y includes a set of values y_i, i=1 to n. The values <x> and <y> represent the average value from the data sets X and Y, respectively. The value s_x and s_y represent the standard deviation of the data sets X and Y, respectively. The correlation coefficient r can thus be used to see to what degree the two (or more) attributes are partially correlated. Thus, FIG. **13** illustrates a map of locations that can represent both a map of attribute one (e.g., where music venue stores are located, which can be illustrated using one dot color, such as red) and a map of attribute two (where drinking establishments are located, which can be illustrated using another dot color, such as green). The correlation index can be calculated to be a value such as 33.7.

CONCLUSION

While various embodiments have been described above, it should be understood that they have been presented by way of example, and not limitation. It will be apparent to persons skilled in the relevant art(s) that various changes in form and detail can be made therein without departing from the spirit and scope. In fact, after reading the above description, it will be apparent to one skilled in the relevant art(s) how to implement alternative embodiments. Thus, the present embodiments should not be limited by any of the above described exemplary embodiments.

In addition, it should be understood that any figures which highlight the functionality and advantages, are presented for example purposes only. The disclosed architecture is sufficiently flexible and configurable, such that it may be utilized in ways other than that shown. For example, the steps listed in any flowchart may be re-ordered or only optionally used in some embodiments. As another example, more than two data sets could be used in each analysis.

Further, the purpose of the Abstract of the Disclosure is to enable the U.S. Patent and Trademark Office and the public generally, and especially the scientists, engineers and practitioners in the art who are not familiar with patent or legal terms or phraseology, to determine quickly from a cursory inspection the nature and essence of the technical disclosure of the application. The Abstract of the Disclosure is not intended to be limiting as to the scope in any way.

Finally, it is the applicant's intent that only claims that include the express language "means for" or "step for" be interpreted under 35 U.S.C. 112, paragraph 6. Claims that do not expressly include the phrase "means for" or "step for" are not to be interpreted under 35 U.S.C. 112, paragraph 6.

What is claimed is:

1. A computerized method for providing mapping, data management and analysis, comprising:
- receiving at a server a user request for creation of a map with a desired Gaussian aggregation and desired color map parameters;
- loading vector geographic data at the server comprising location data, the location data comprising at least one attribute;
- rasterizing the vector geographic data to create image data composed of pixels;
- converting the image data to a certain scale grayscale image data;
- performing a convolution operation on the grayscale image data to provide an aggregation of the data using a kernel radius wherein the kernel radius is adjusted in accordance with the desired zoom level;
- applying convolution results to a color ramp;
- creating the map for the location data based on the color ramp and the convolution results; and
- providing the map to the user.

2. The method of claim **1**, wherein an additional mathematical operation is performed to analyze the data.

3. The method of claim **2**, wherein the mathematical operation is:
- addition/integration;
- subtraction;
- multiplication; or
- a linear correlation; or
- any combination thereof.

4. The method of claim **3**, further comprising employing the multiplication to perform an intersection analysis.

5. The method of claim **3**, further comprising employing the subtraction to perform a temporal analysis.

6. The method of claim **3**, further comprising employing the addition/integration to perform a special concentration analysis.

7. The method of claim **3**, further comprising employing a linear correlation function to perform a correlation analysis.

8. The method of claim **1**, further comprising delivering the map through a Web browser.

9. The method of claim **1**, wherein the map is dynamically re-created as users zoom in and out or as temporal data feeds change.

10. The method of claim **1**, wherein the method utilizes a bounding box and tiling technique to provide panning of raster analysis across the map.

11. The method of claim **1**, wherein the data comprises user-generated vector data.

12. The method of claim **1**, wherein the convolution is a Gaussian aggregation and the kernel radius is a Gaussian distance decay function.

13. The method of claim **1**, wherein the data comprises user-generated vector data.

14. The method of claim **1**, wherein the convolution operation is performed on the grayscale image data within the confines of a viewing boundary box around part of the grayscale image data in accordance with zoom and panning operations performed by the user.

15. The method of claim **14**, wherein the viewing boundary box comprises a buffer around its periphery based on the kernel radius to produce an additional region of image around the viewing boundary box.

16. The method of claim 15, further comprising:
receiving a request from the user to pan the map; and
providing an updated map to the user including at least some of the image from the buffer.

17. A system for providing mapping, data management and analysis, comprising:
a processing device comprising a server coupled to a network;
a database accessible by the server; and
an application coupled to the server, the application configured to:
receive at a server a user request for creation of a map with a desired Gaussian aggregation and desired color map parameters;
load vector geographic data at the server comprising location data, the location data comprising at least one attribute;
rasterize the vector geographic data to create image data composed of pixels;
converting the image data to a certain scale grayscale image data;
perform a convolution operation on the grayscale image data to provide an aggregation of the data using a kernel radius wherein the kernel radius is adjusted in accordance with the desired zoom level;
apply convolution results to a color ramp;
create the map for the location data based on the color ramp and the convolution results; and
providing the map to the user.

18. The system of claim 17, wherein the application is further configured to perform an additional mathematical operation to analyze the data.

19. The system of claim 18, wherein the mathematical operation is:
addition/integration;
subtraction;
multiplication; or
a linear correlation; or
any combination thereof.

20. The system of claim 19, wherein the application is further configured to employ the multiplication to perform an intersection analysis.

21. The system of claim 19, wherein the application is further configured to employ the subtraction to perform a temporal analysis.

22. The system of claim 19, wherein the application is further configured to employ the addition/integration to perform a special concentration analysis.

23. The system of claim 19, wherein the application is further configured to employ a linear correlation function to perform a correlation analysis.

24. The system of claim 17, wherein the application is further configured to deliver the map through a Web browser.

25. The system of claim 17, wherein the map is dynamically re-created as users zoom in and out or as temporal data feeds change.

26. The system of claim 17, wherein the application utilizes a bounding box and tiling technique to provide panning of raster analysis across the map.

27. The system of claim 17, wherein the data comprises user-generated vector data.

28. The system of claim 17, wherein the convolution is a Gaussian aggregation and the kernel radius is a Gaussian distance decay function.

29. The system of claim 17, wherein the data comprises user-generated vector data.

30. The system of claim 17, wherein the convolution operation is performed on the grayscale image data within the confines of a viewing boundary box around part of the grayscale image data in accordance with zoom and panning operations performed by the user.

31. The system of claim 30, wherein the viewing boundary box comprises a buffer around its periphery based on the kernel radius to produce an additional region of image around the viewing boundary box.

32. The system of claim 31, wherein the application is further configured to:
receive a request from the user to pan the map; and
provide an updated map to the user including at least some of the image from the buffer.

* * * * *